



## Berøringsløs optisk måling af gassammensætning ved UV og IR spektroskopi

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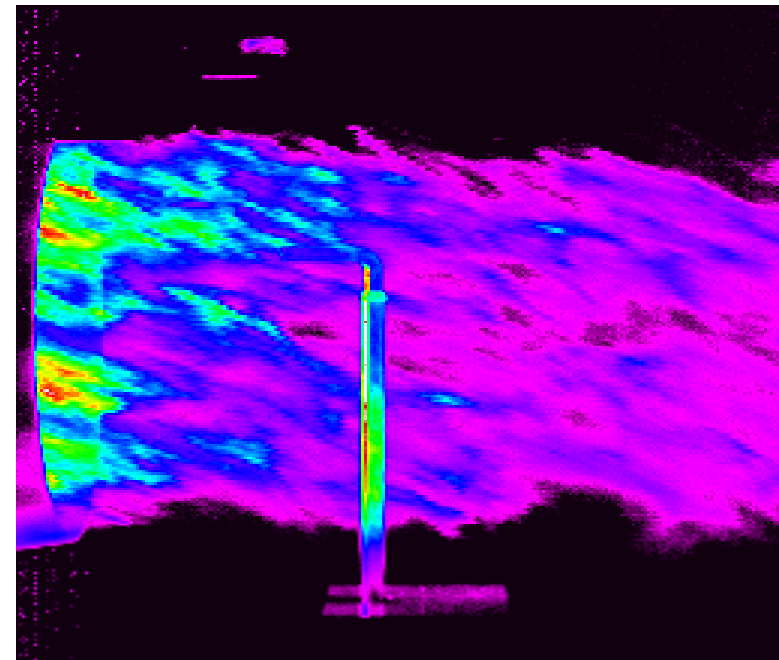
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# Berøringsløs optisk måling af gassammensætning ved UV og IR spektroskopi

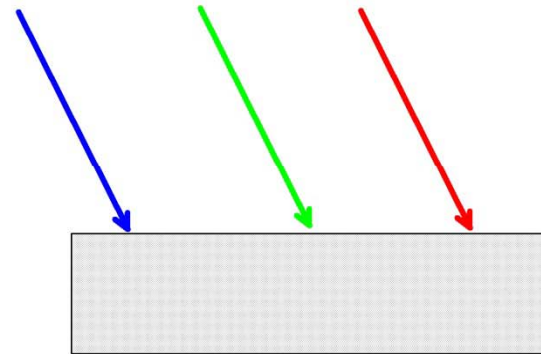
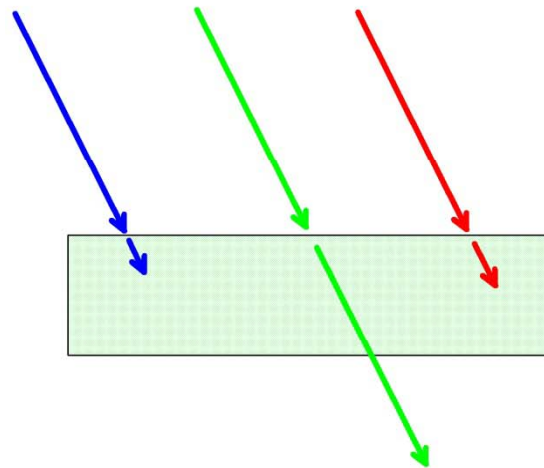
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# OPTICAL METHODS

- Gas temperature and composition
- Hot gas flow with dust
- Fast response time
- Large range
- Fiber optics
- 1 - ? process points
- Non-intrusive



# ABSORPTION

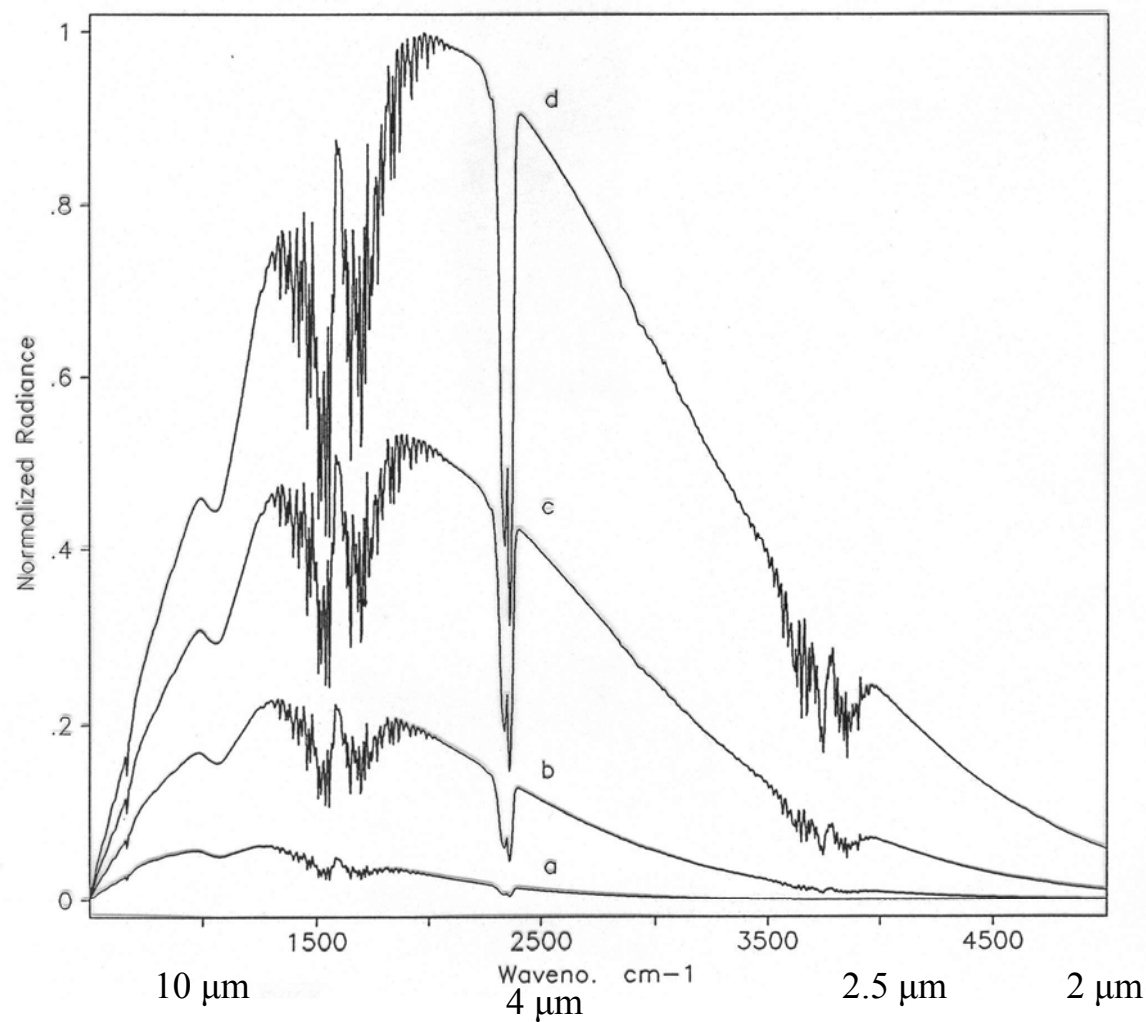


Beer's Law:

$$I = I_0 e^{-abc}$$

# Blackbody-kurver

## MÅLT (FTIR)



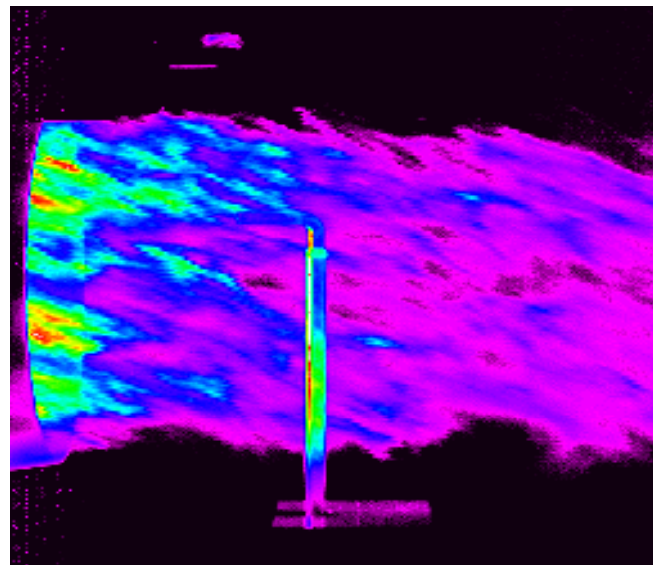
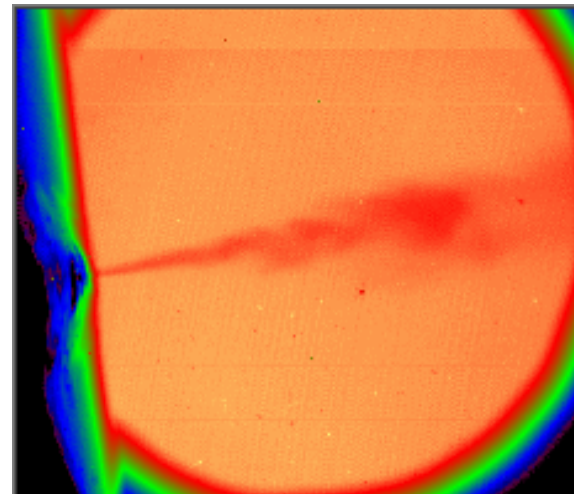
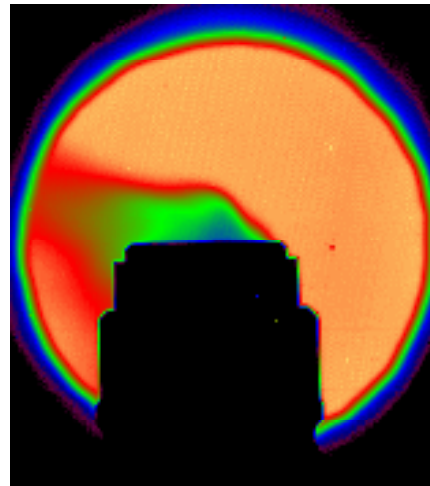
# Measurement Techniques

## FULL SCALE

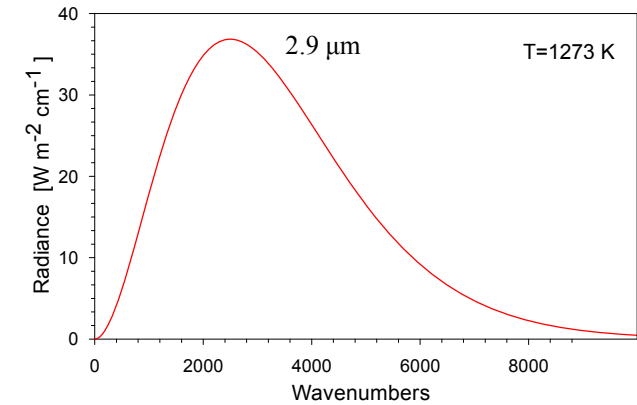
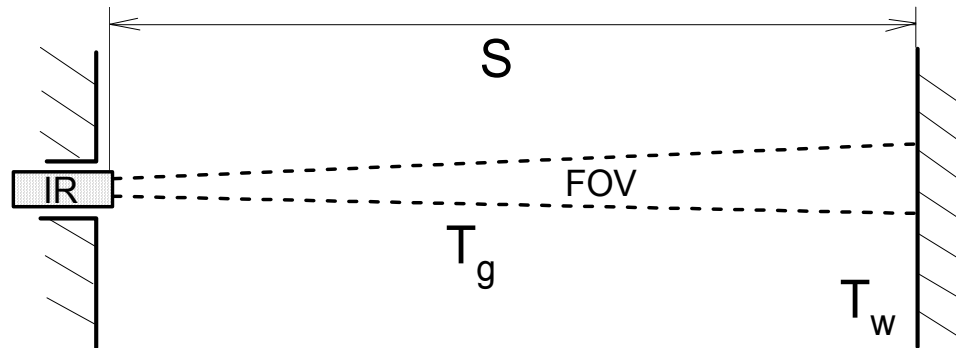


- CCD / IR pictures (e.g. high speed IR-camera)
- FTIR emission spectroscopy (2-6  $\mu\text{m}$ )  
(CO, CO<sub>2</sub>, H<sub>2</sub>O, C<sub>x</sub>H<sub>y</sub>, T<sub>gas</sub>, T<sub>par</sub>, flux)
- UV transmittance spectroscopy (210-350 nm)  
(NO, O<sub>2</sub>, SO<sub>2</sub>,...)

# CCD and IR pictures



# Theory – Principles



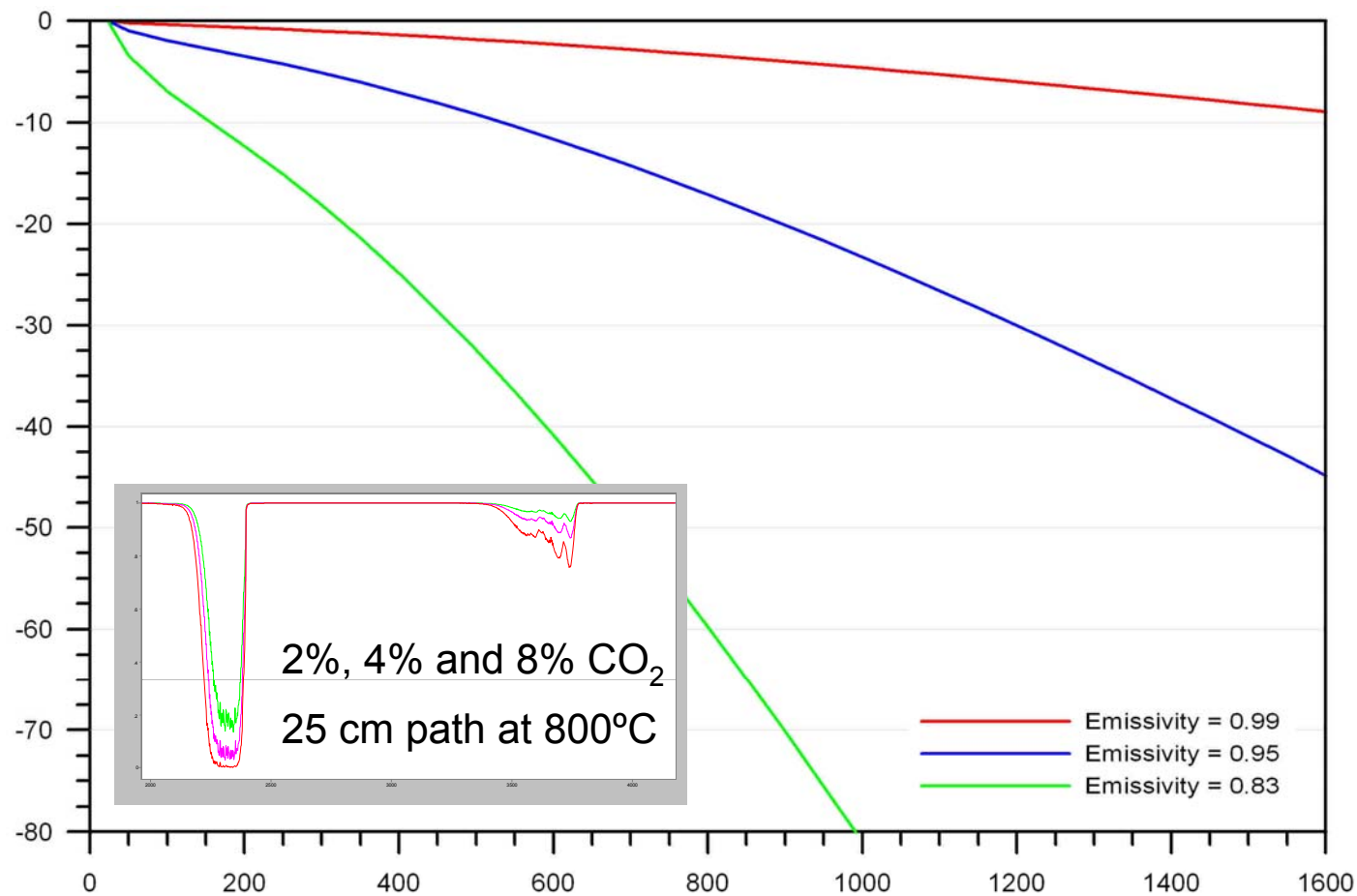
$$(1) \quad L_m(\lambda) = \varepsilon(\lambda, T_{g, c_i}) L(\lambda, T_g) + \tau(\lambda, T_{g, c_i}) L(\lambda, T_w)$$

$$(2a) \quad \varepsilon(\lambda, T_{g, c_i}) = \alpha(\lambda, T_{g, c_i}), \quad (2b) \quad \tilde{\nu} = \frac{1}{\lambda}$$

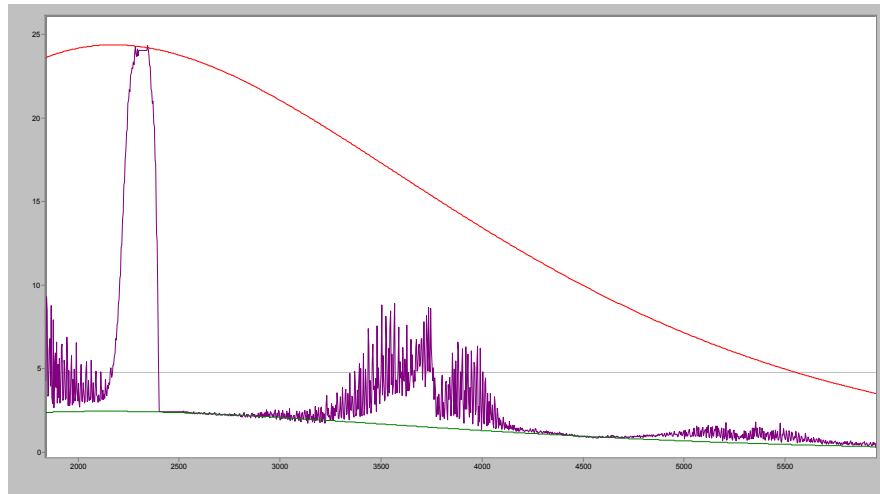
$$(3) \quad \alpha(\lambda, T_g) = \frac{L_m(\lambda) - L(\lambda, T_w)}{L(\lambda, T_g) - L(\lambda, T_w)}$$



# Gas temperature



# IR gas analysis



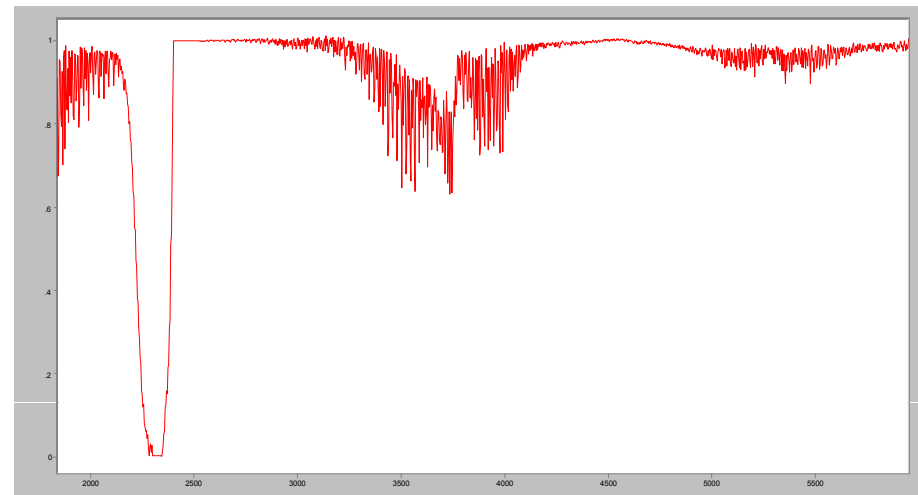
Emission spectrum:

GB: 816.9°C,  $\varepsilon=0.106$

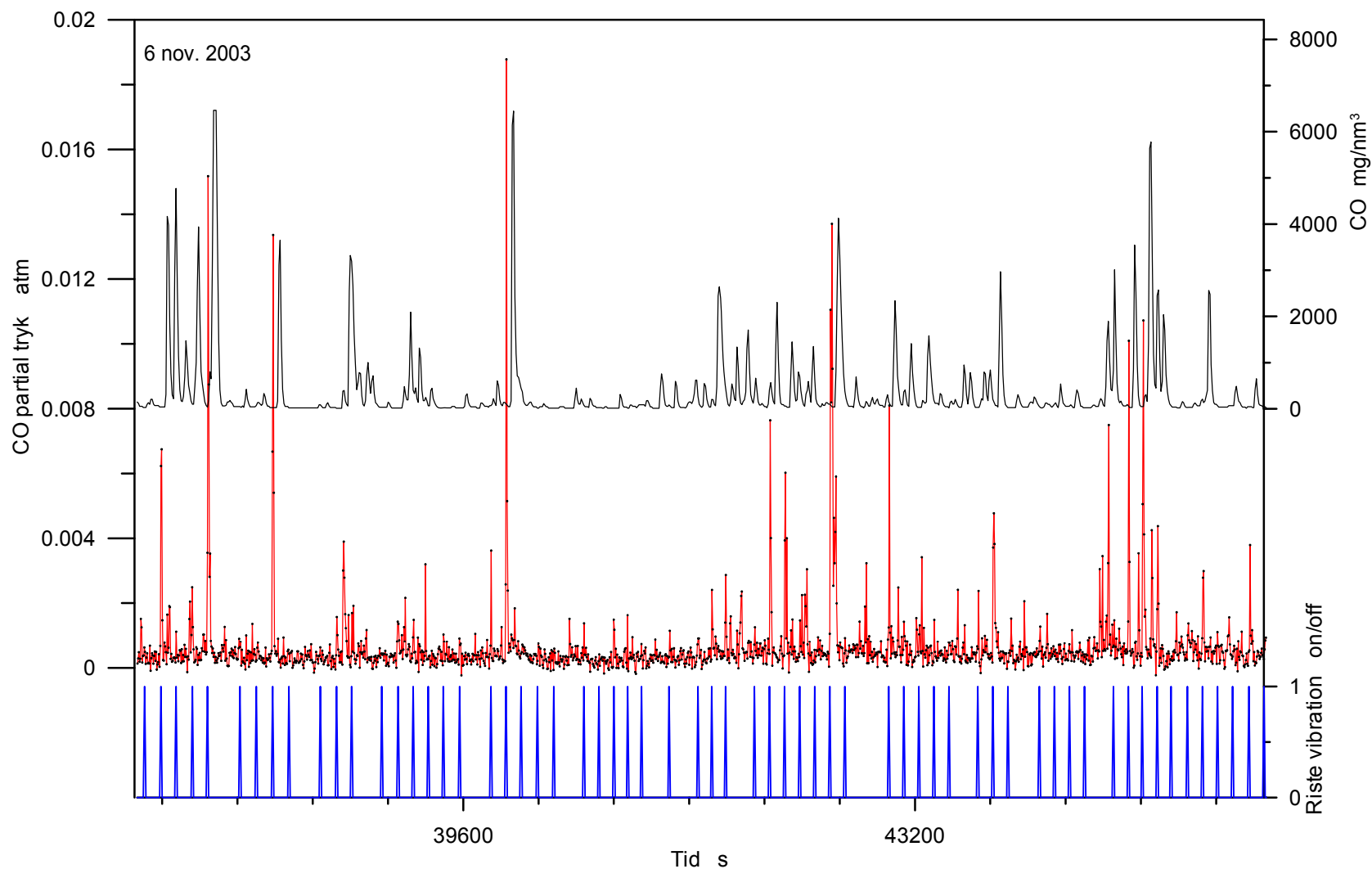
Blackbody curve at 836.0°C

Transmittance spectrum

CO<sub>2</sub>, H<sub>2</sub>O, CO, C<sub>x</sub>H<sub>y</sub>, ...

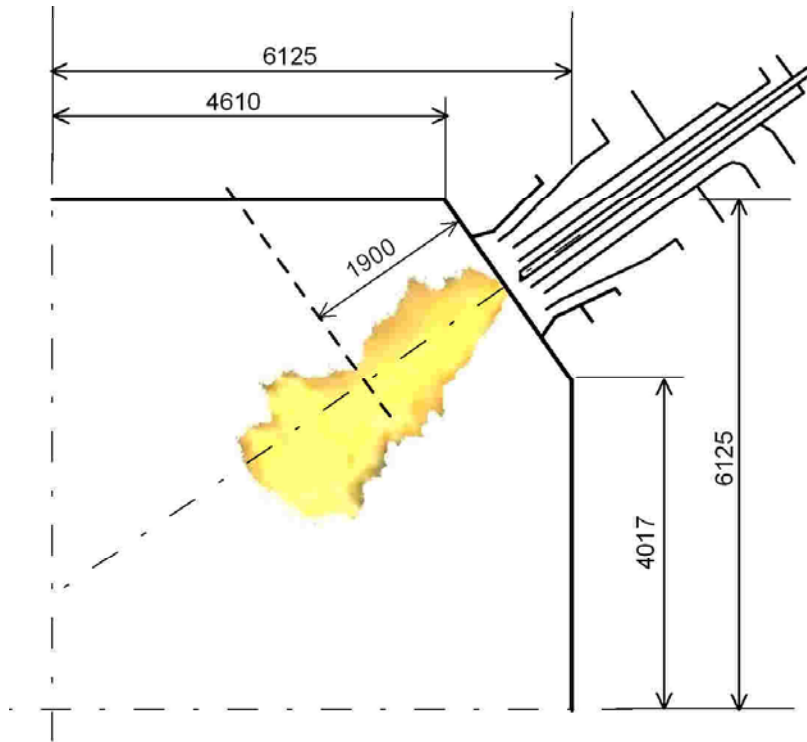


# CO Concentration



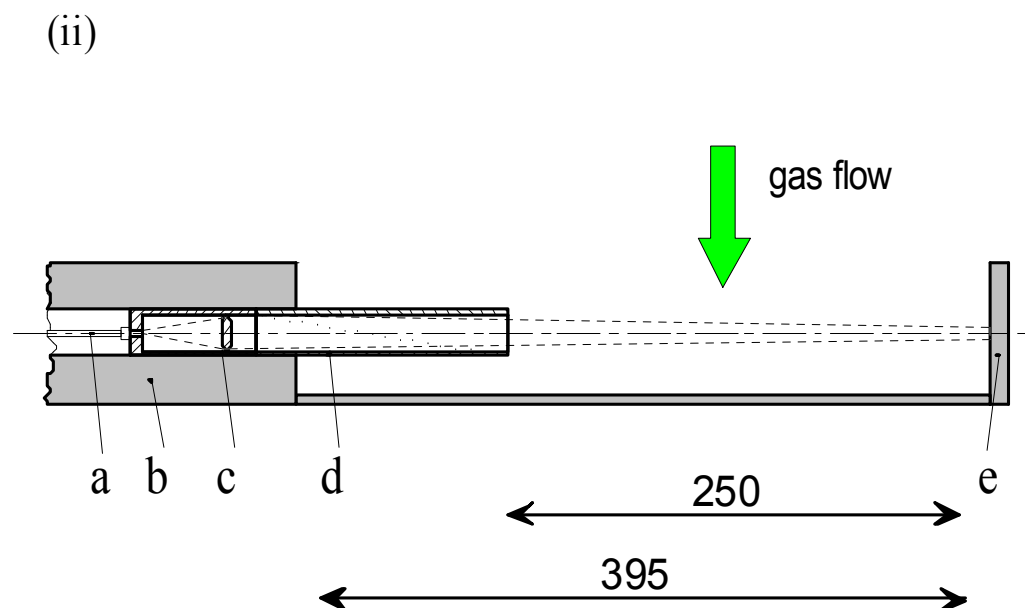
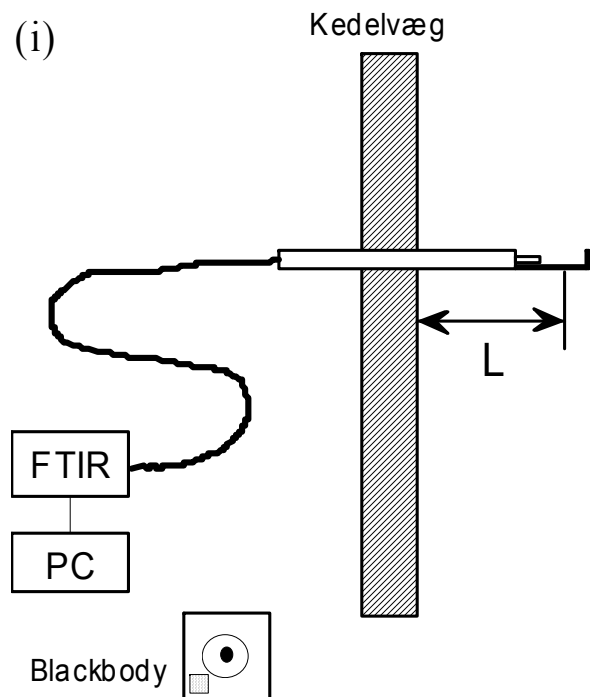
# FTIR flame measurements

AVV2 April 2006

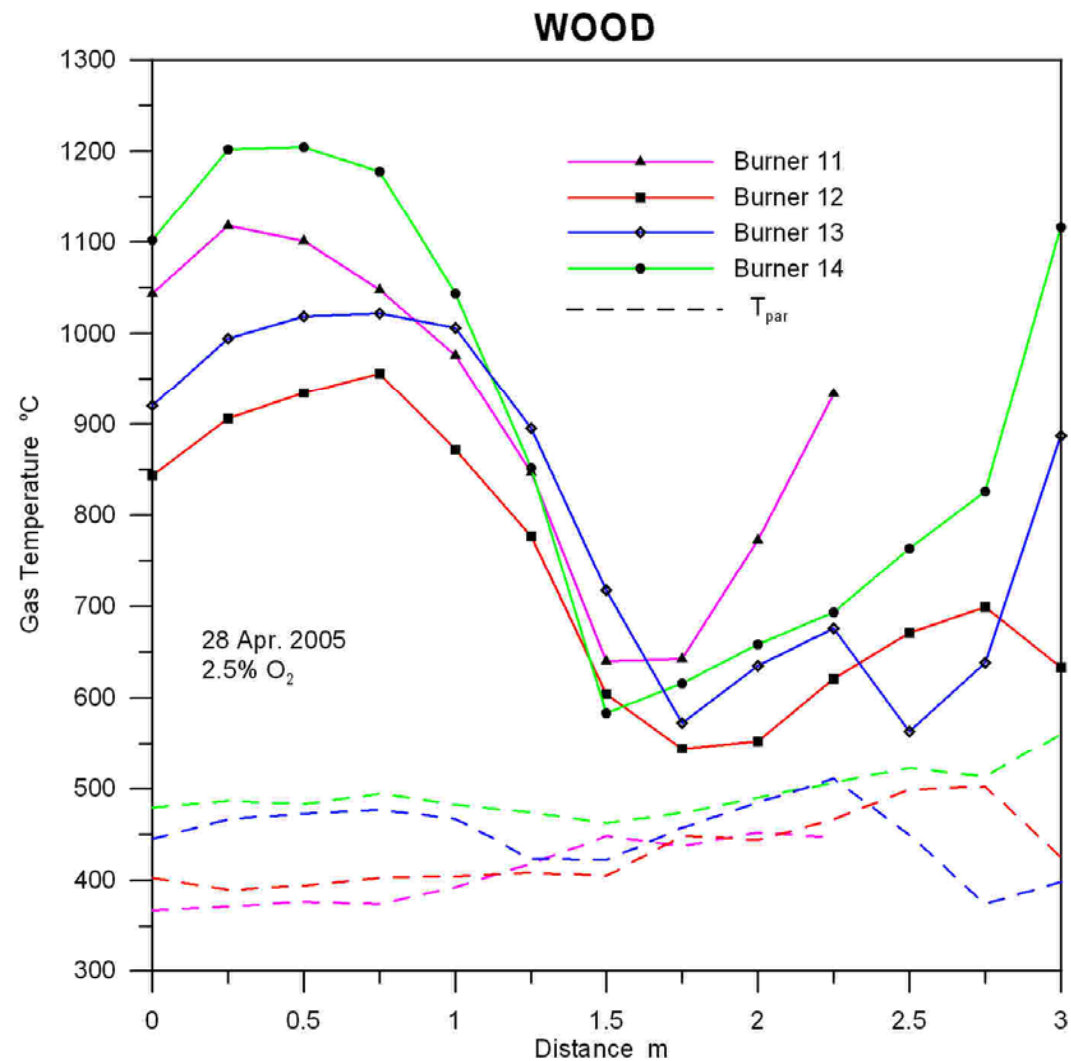


Wood flame

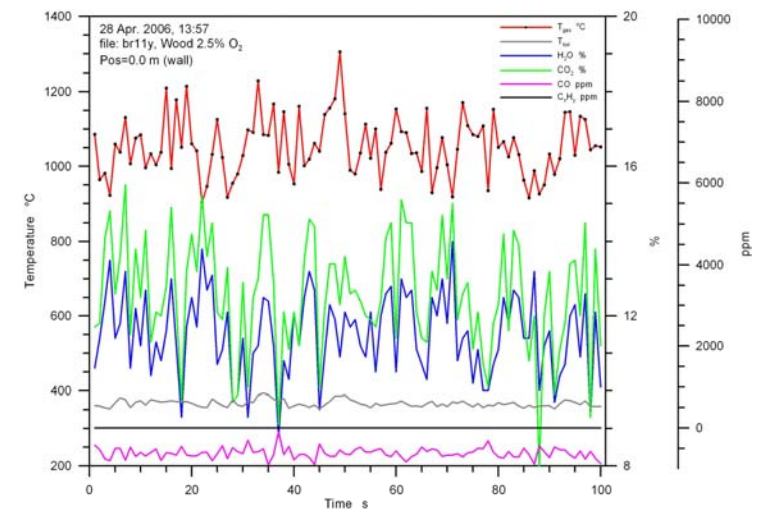
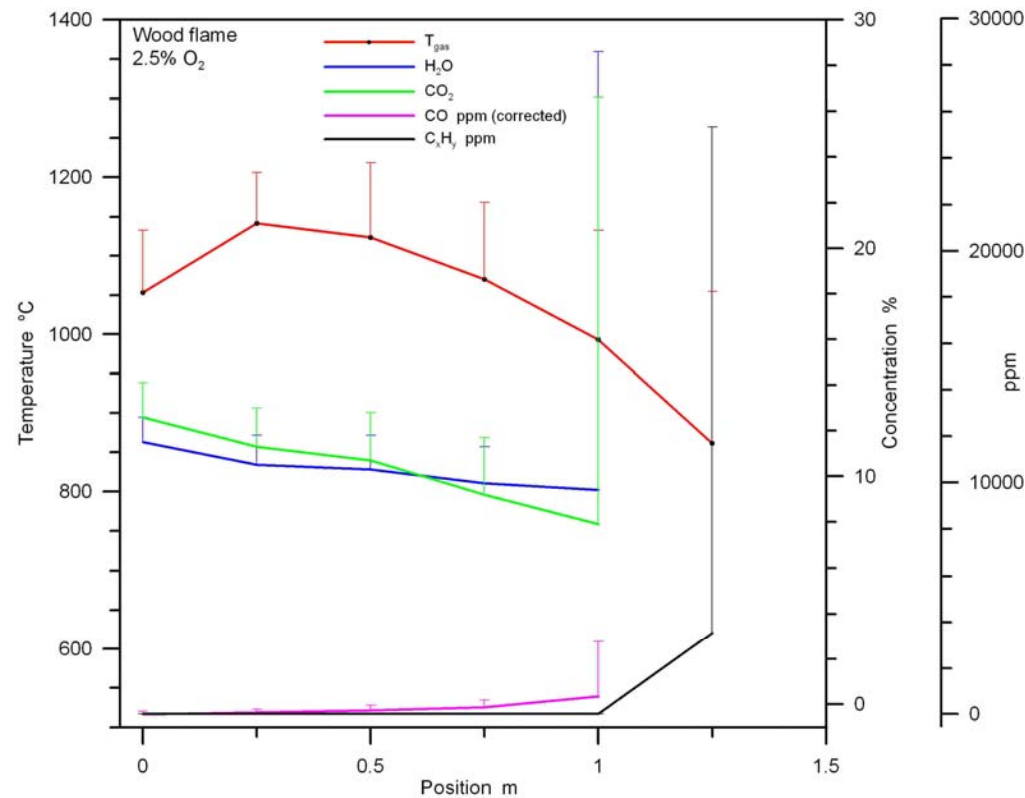
# FTIR spectroscopy



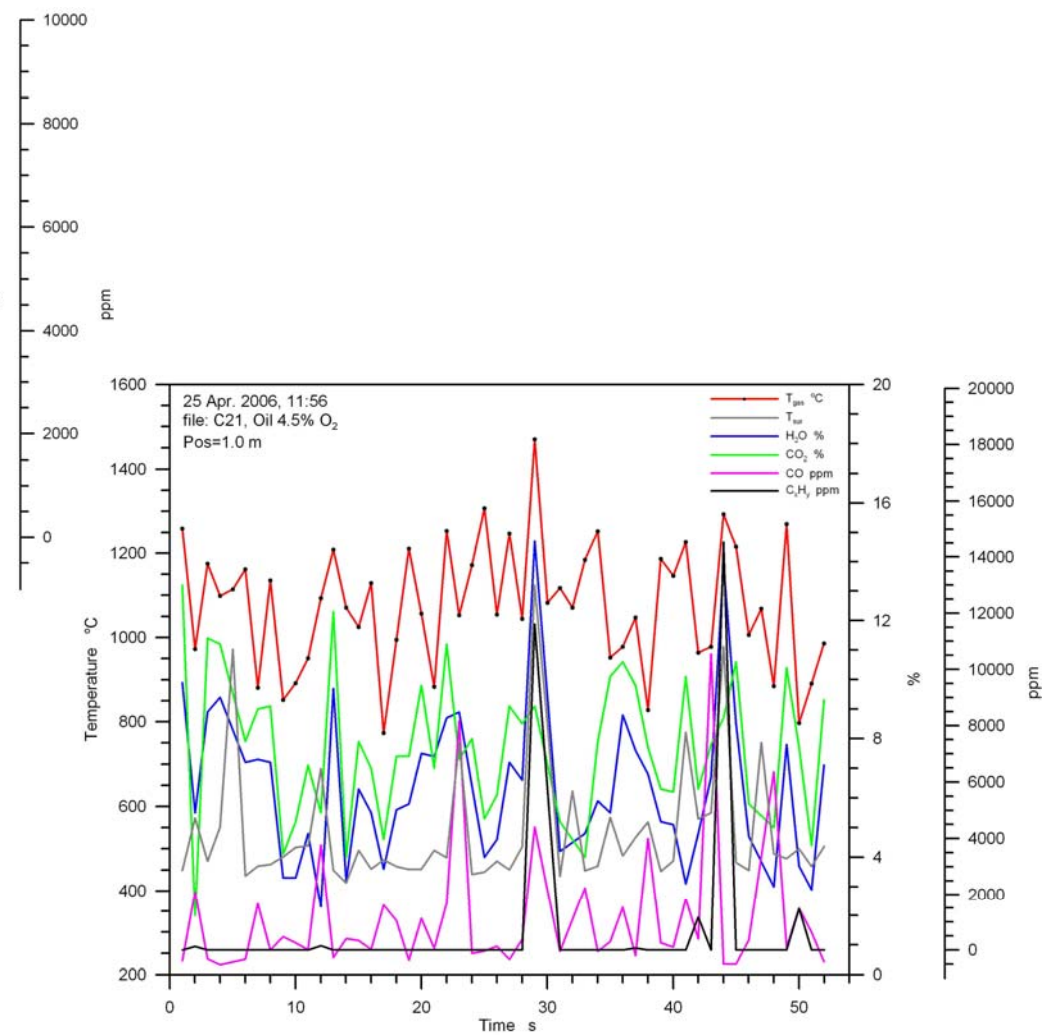
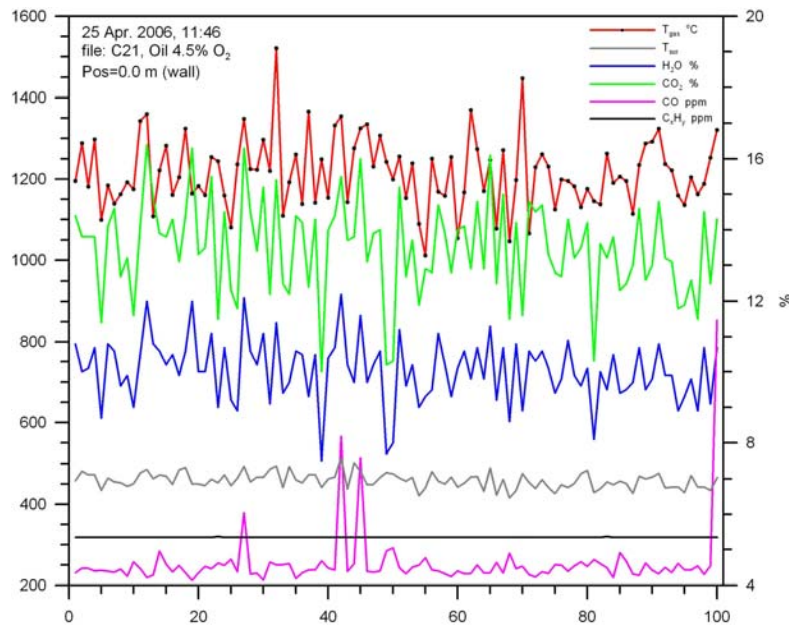
# Wood flame temperature



# Wood flame gas conc.

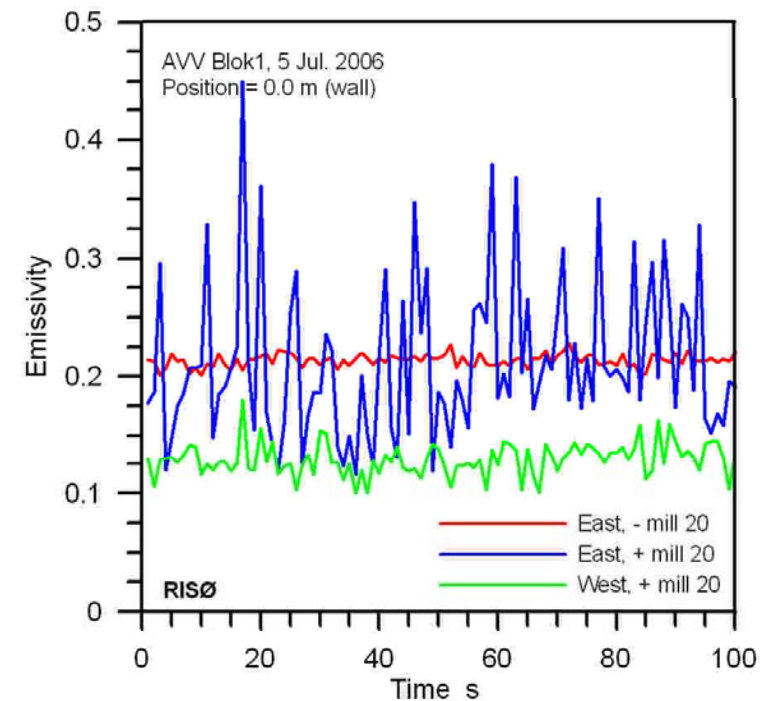
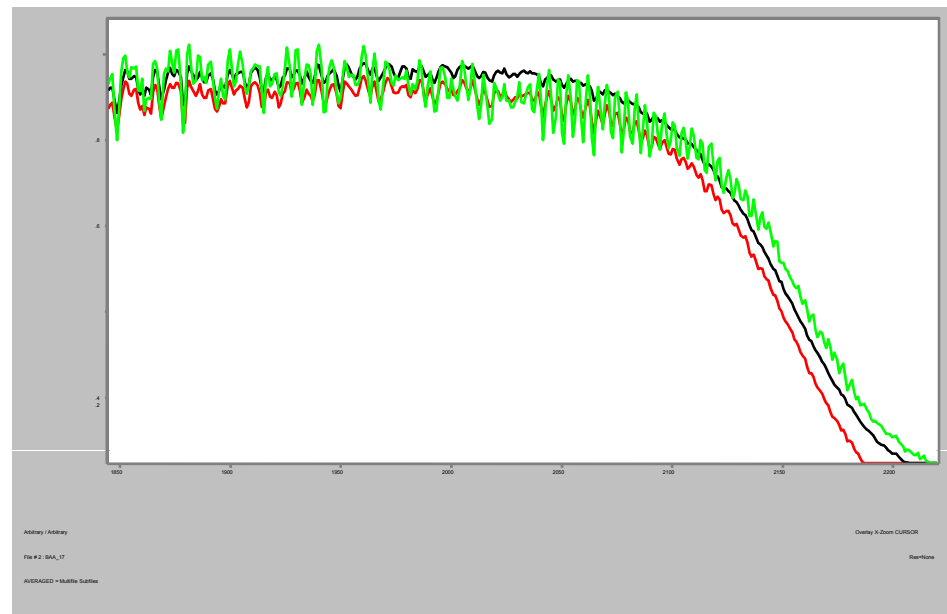


# Oil flame



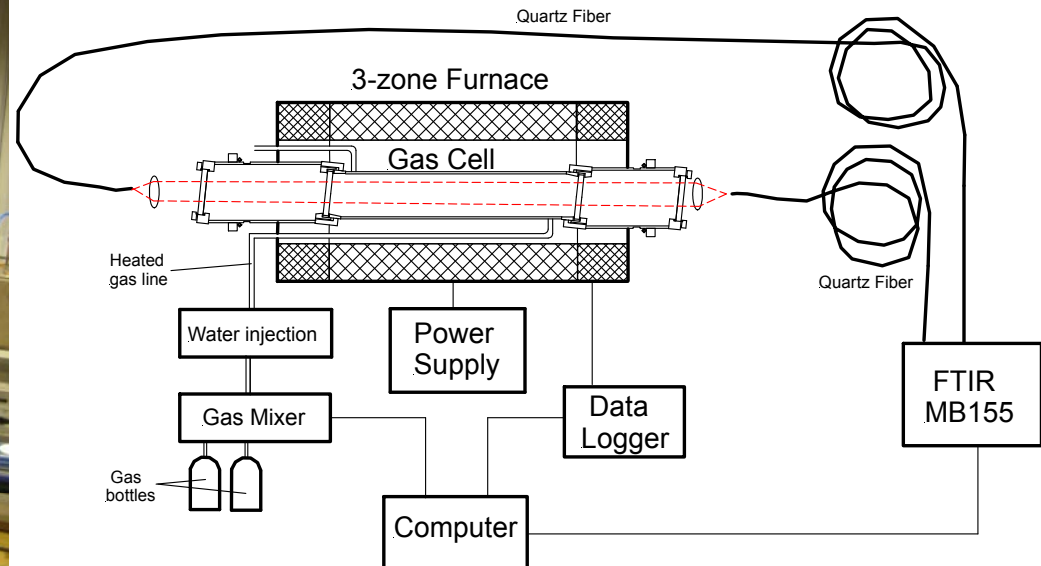
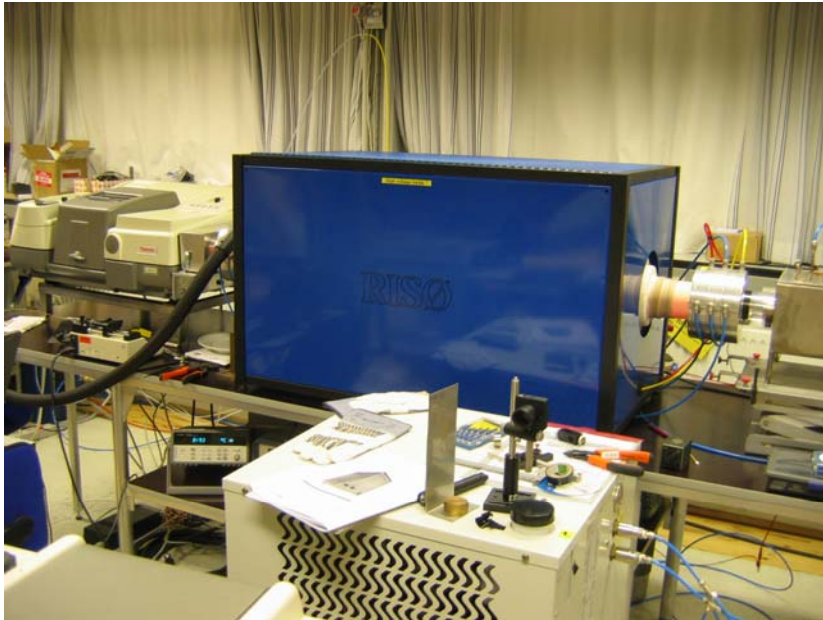


# Coal flame



$T_g$ ,  $T_p$ ,  $CO$ ,  $CO_2$ ,  $H_2O$ ,...

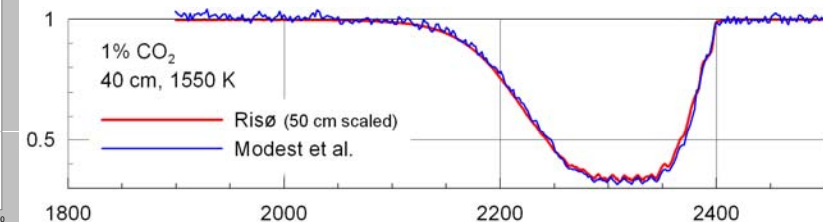
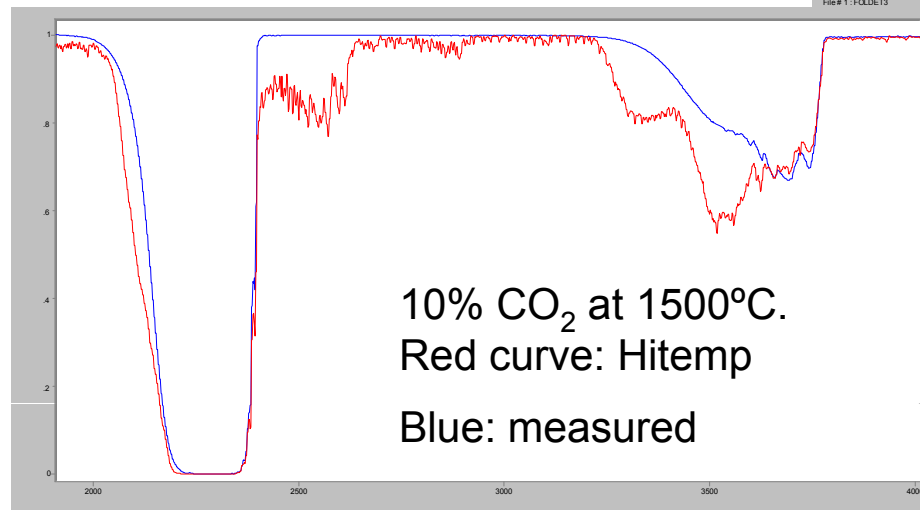
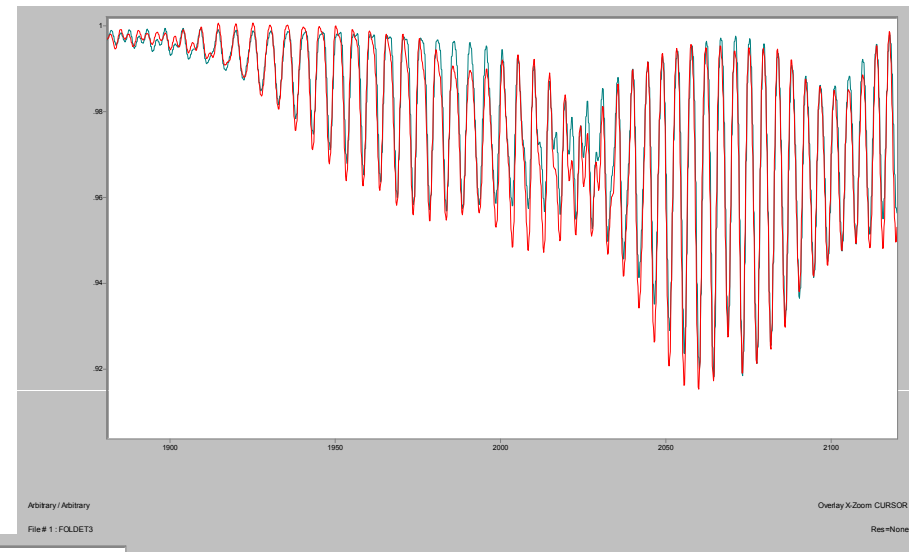
# Hot gas cell



Temperature range: 23 °C - 1600°C  
UV, VIS, IR, FAR,...

# Gas reference data

Measured 1% CO spectrum  
in hot gas cell at 1500°C (red)



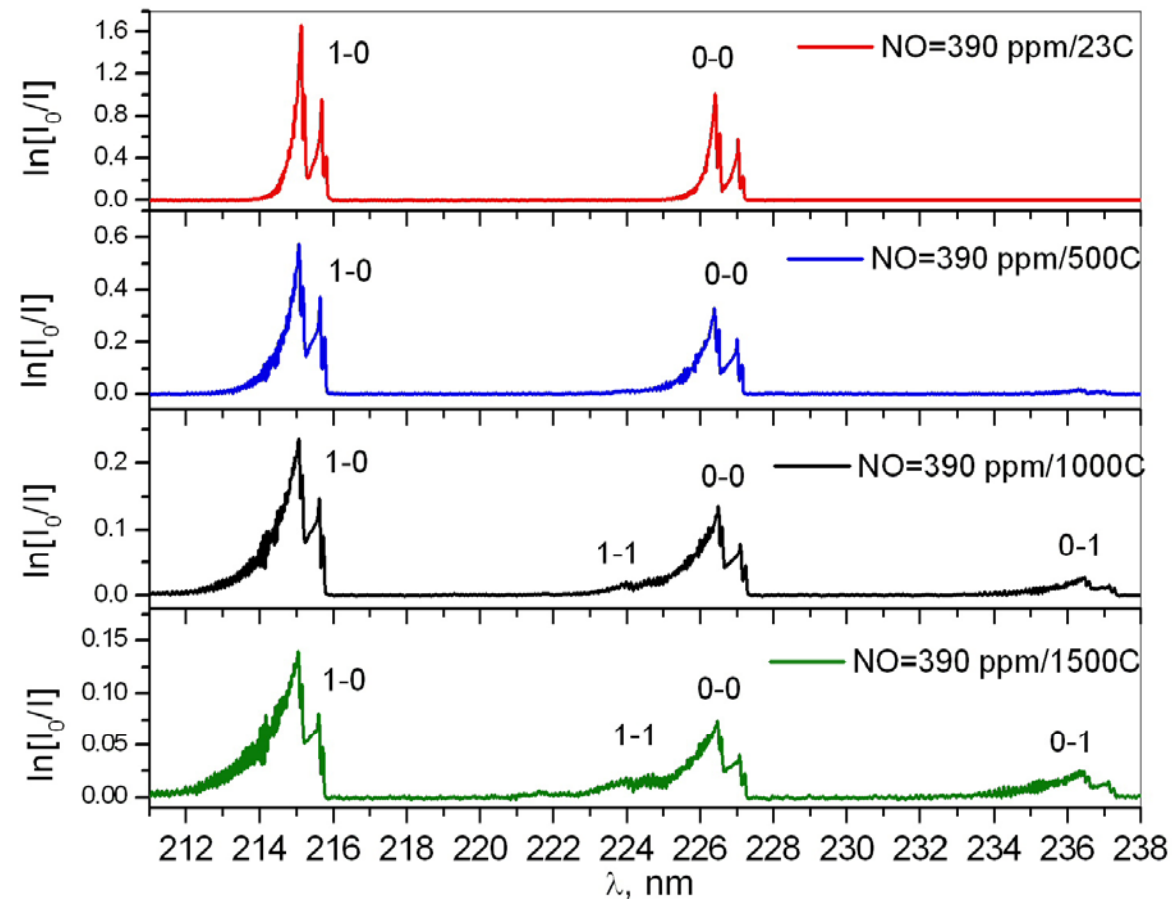
# UV spectroscopy



Strong	Weak
<p>Non-contact multi-gas analyzer for important combustion gases (<math>O_2</math>, NO, <math>SO_2</math>).</p> <p>Interference from <math>H_2O</math> and <math>CO_2</math> is a minor problem.</p> <p>UV and IR method can be combined for non-contact, simultaneously and accurate measurement of gas temperature and gas composition (<math>O_2</math>, NO, <math>SO_2</math>, CO, <math>CO_2</math>, <math>H_2O</math>, HCl, <math>C_xH_y</math>,...).</p> <p>Measuring time can in principle be few <math>\mu s</math> using pulsed UV source combined with fast and sensitive detector array (peltier cooled).</p> <p>Quartz fibre optics can be used in applications.</p> <p>High sensitivity NO and <math>SO_2</math>.</p>	<p>Short lifetime of UV source.</p> <p>Safety UV radiation (eye and skin).</p> <p><math>SO_2</math> limits applications.</p> <p>Reduced throughput for long fibre (<math>&gt;10</math> m).</p> <p>System stability requires great effort (vibration, ambient temperature, dust,...).</p> <p>Aging of system optical components due UV radiation could be a problem.</p> <p>Path length limitations for some applications.</p> <p>More sensitive to soot and particles in gas compared with IR techniques</p>

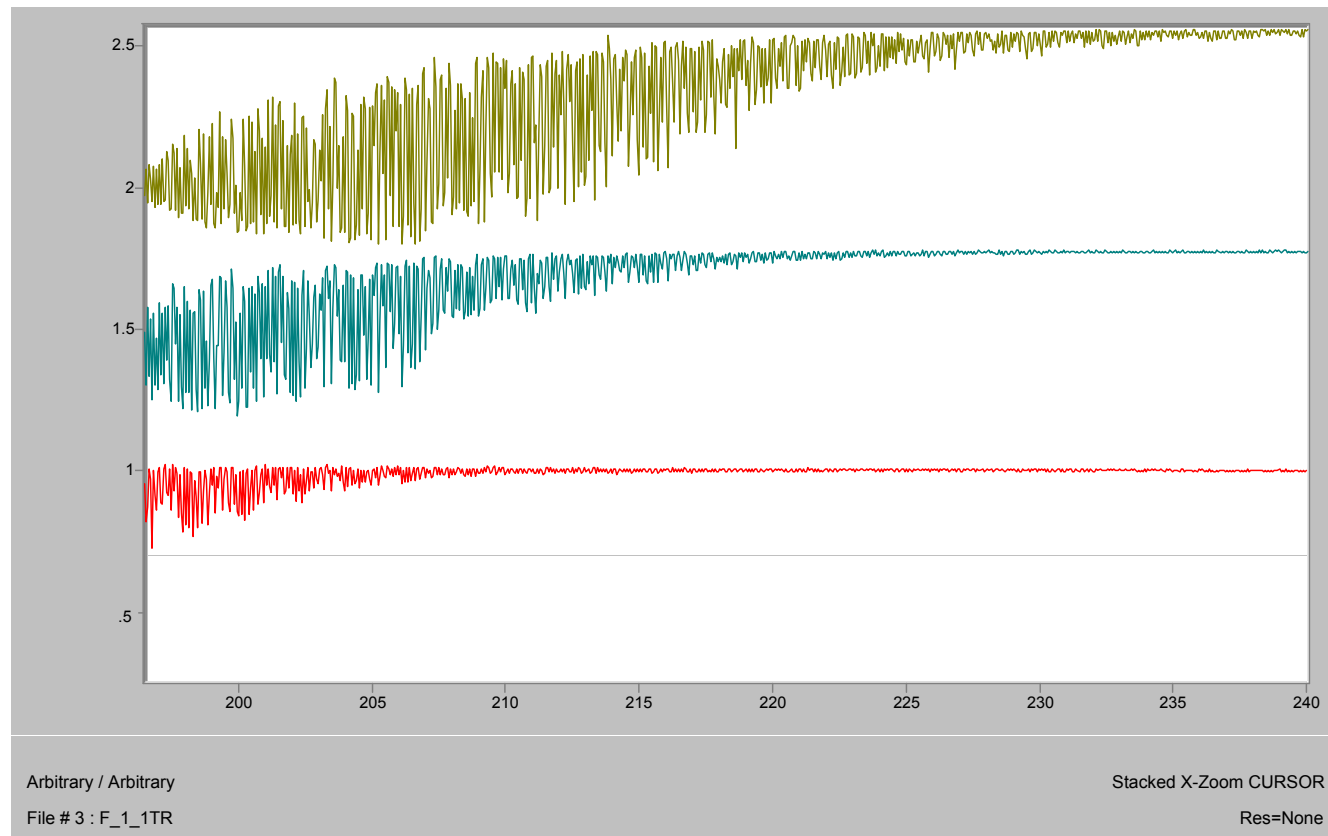
# UV NO detection

$\lambda=215$  nm absorption band:  $DT=DT_{rot} \pm 50^\circ\text{C}$



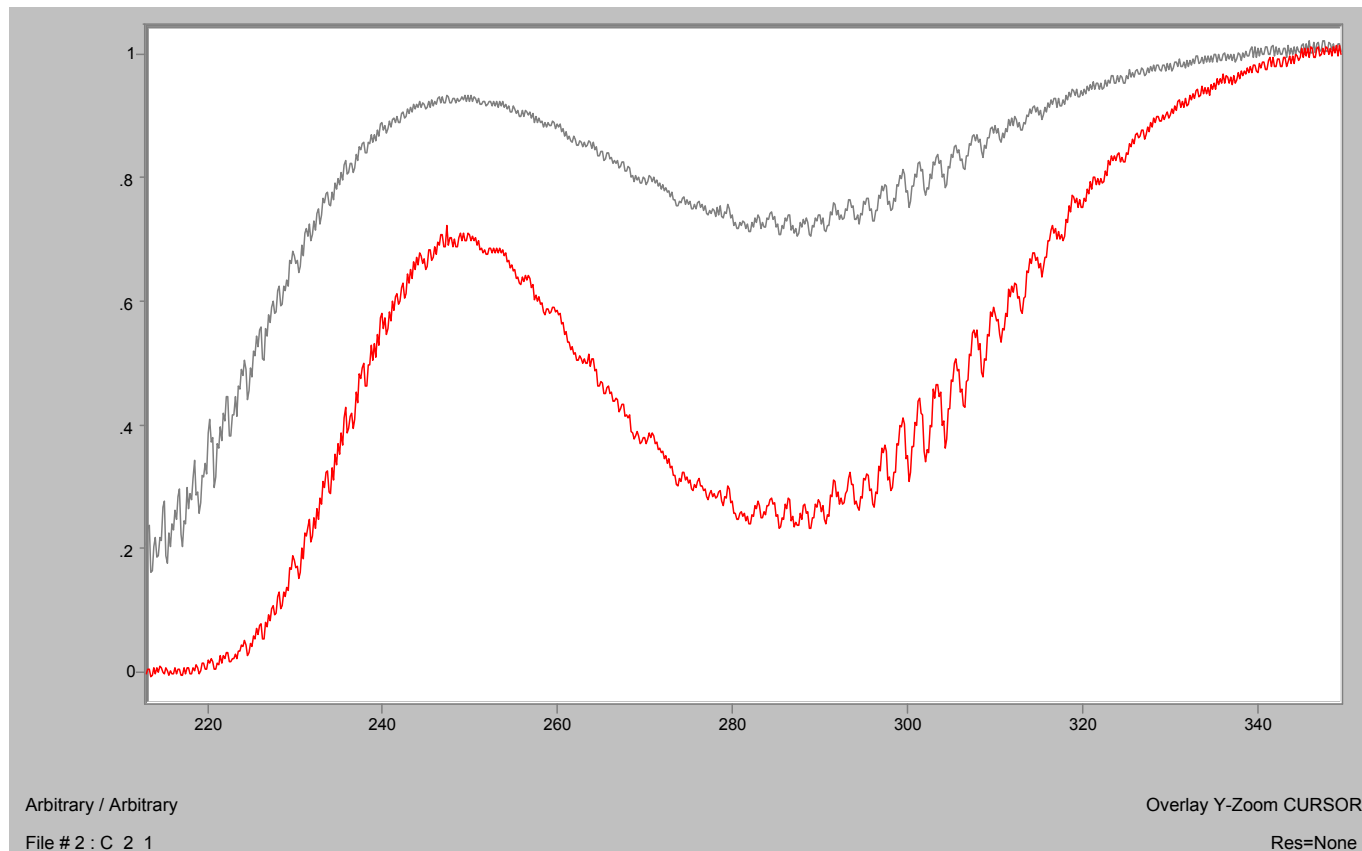
Paper: *In-situ Gas temperature measurements by UV-absorption spectroscopy*

# UV O<sub>2</sub> detection



21% O<sub>2</sub> at 400°C (red), 700°C (cyan) and 1000°C (green), 53.3 cm path length

# UV SO<sub>2</sub> detection



Transmittance at 700°C, 53.3 cm path length.  
Grey curve 1154 ppm SO<sub>2</sub> in N<sub>2</sub> and red 5000 ppm in N<sub>2</sub>

Kontakt/spørgsmål:

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